



EWEA CREYAP benchmark exercises: summary for offshore wind farm cases

Mortensen, Niels Gylling; Nielsen, Morten; Ejsing Jørgensen, Hans

Publication date:
2015

Document Version
Peer reviewed version

[Link back to DTU Orbit](#)

Citation (APA):
Mortensen, N. G. (Author), Nielsen, M. (Author), & Ejsing Jørgensen, H. (Author). (2015). EWEA CREYAP benchmark exercises: summary for offshore wind farm cases. Sound/Visual production (digital)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

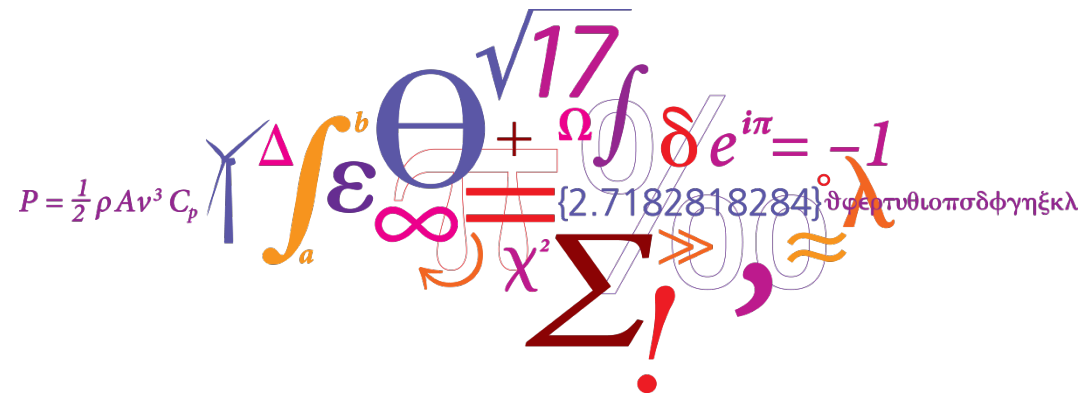
- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

EWEA CREYAP benchmark exercises: summary for offshore wind farm cases

Niels G Mortensen, Morten Nielsen & Hans E Jørgensen

Wind Energy Denmark 2015



Acknowledgements

- RES Ltd. for Gwynt y Môr data pack
- DONG Energy Wind Power A/S for Barrow data
- Dong Energy, Iberdrola and Crown Estate for Shell Flats wind data and other information.
- 60 teams from 13 countries; thanks for making the comparison and presentations possible!
- EWEA for arranging Offshore CREYAP Part 1+2, thanks to Tim Robinson and his team.

Comparison of Resource and Energy Yield Assessment Procedures

EWEA CREYAP concept

- Industry benchmarking
- In-house training and R&D
- Identification of R&D issues

Three issues today

- Wakes and wake modelling
- Yield assessment uncertainties
- Modelled vs observed yields

CREYAP history

- Onshore Part 1, Bruxelles 2011
 - Scotland W, 14×2 MW (28 MW)
- Onshore Part 2, Dublin 2013
 - Scotland E, 22×1.3 MW (29 MW)
- Offshore Part 1, Frankfurt 2013
 - Gwynt y Môr, 160×3.6 (576 MW)
- Offshore Part 2, Helsinki 2015
 - Barrow, 30×3 MW (90 MW)

Summary

- 157 submissions from 27 countries
 - 97 for onshore
 - 60 for offshore

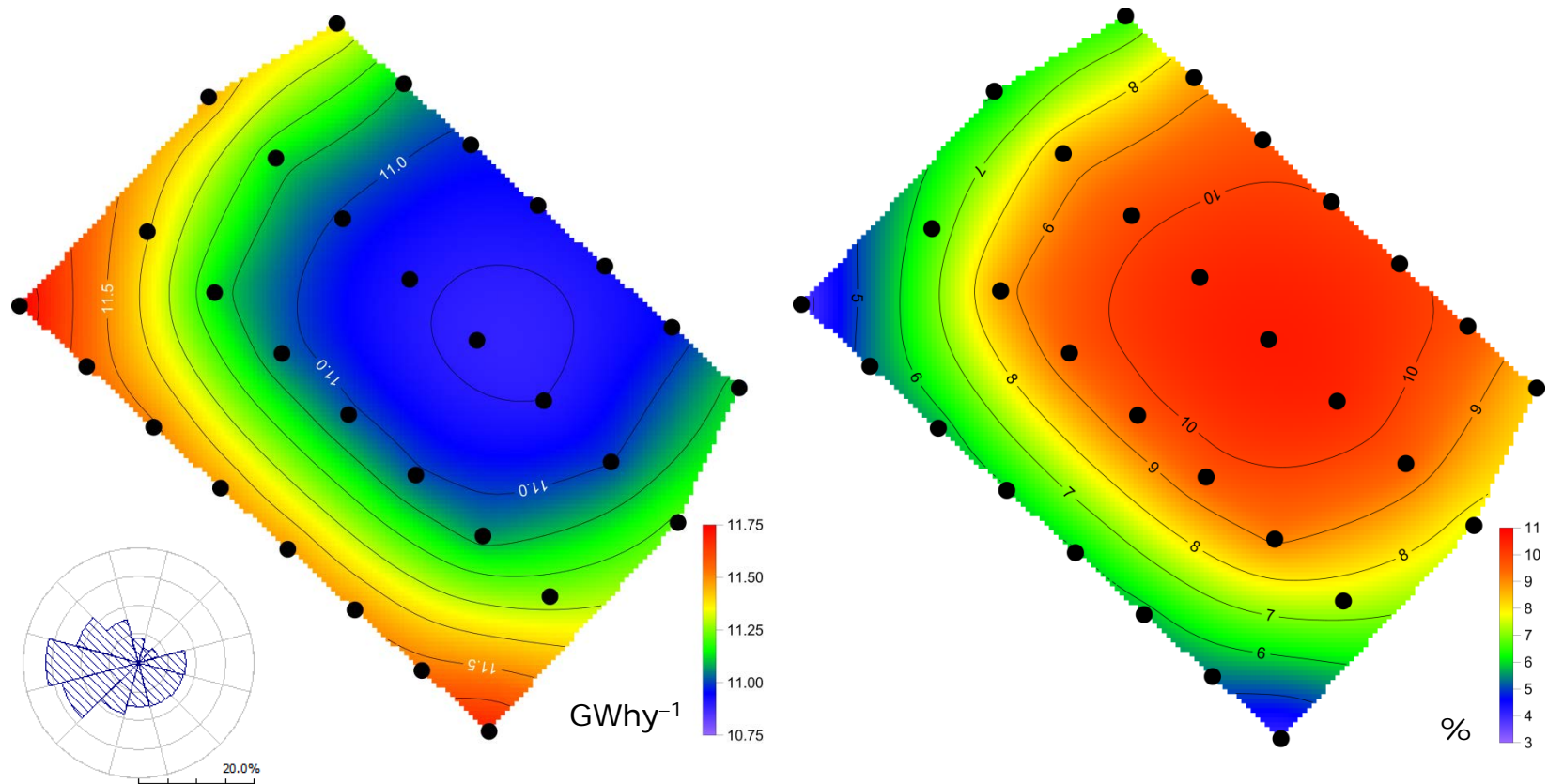


Gwynt y Môr

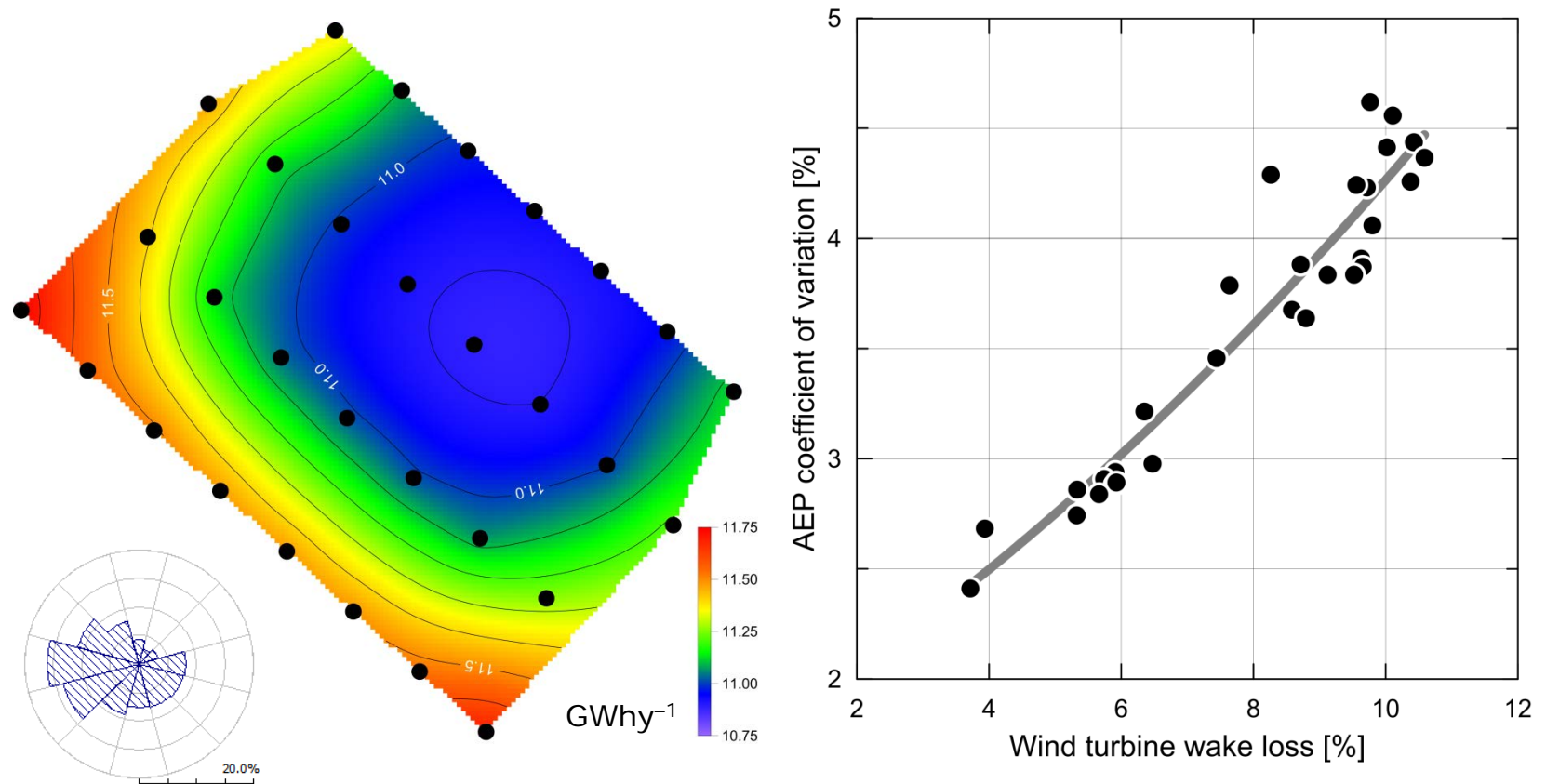


Barrow

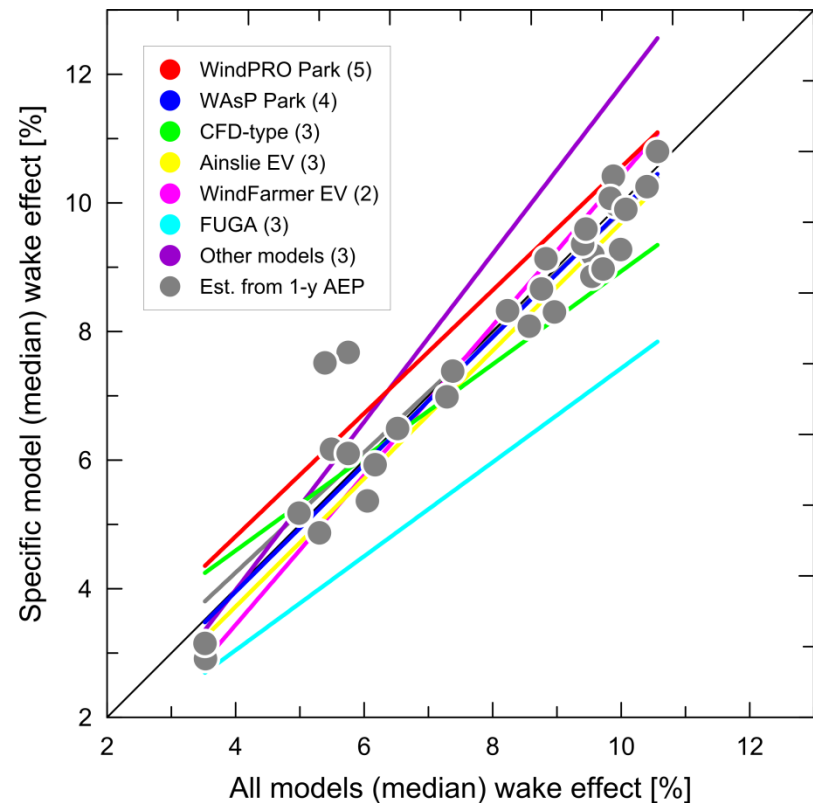
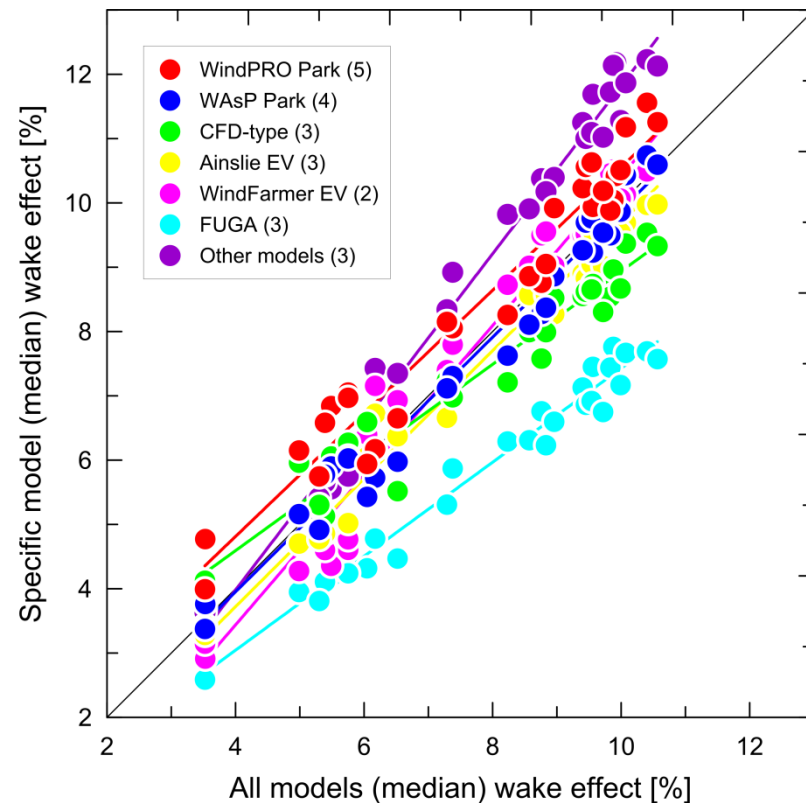
Barrow estimated turbine yields and wake effects



Barrow estimated turbine yields and spread of results



Barrow wind farm (only) – which wake model is best?



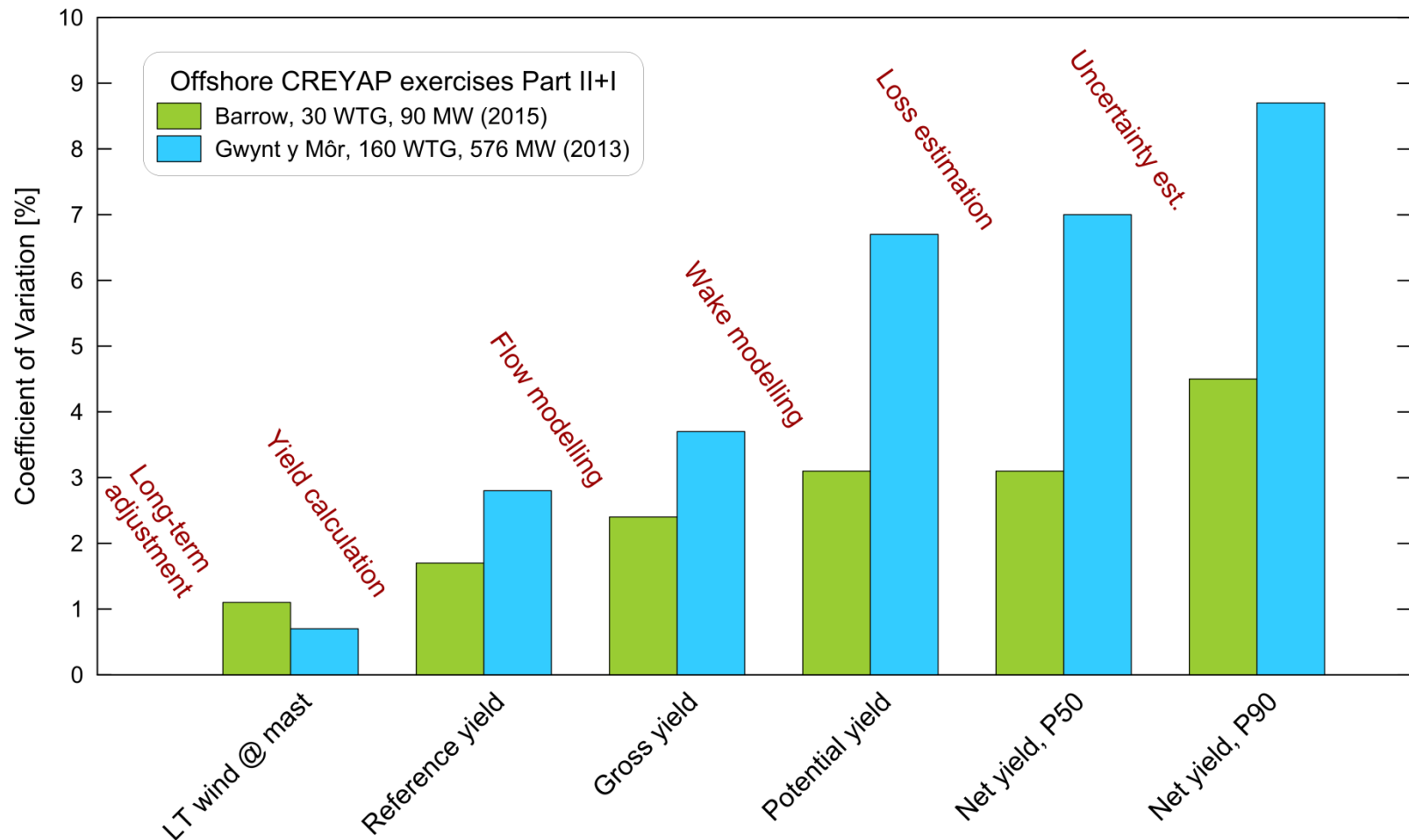
Wake modelling uncertainty (CREYAP 1-4, Nygaard 2015)

Wind farm	Size	Layout	Wake loss	Uncertainty
Onshore 1 Hilly	28 MW 14 WTG	Irregular 3.7-4.8 <i>D</i>	6.1%	13%
Onshore 2 Complex	29 MW 22 WTG	Irregular 4-5 <i>D</i>	10.3%	18%
Offshore 1† Gwynt y Môr	576 MW 160 WTG	Regular 6-7 <i>D</i>	14.3%	22%
Offshore 2 Barrow	90 MW 30 WTG	4 staggered 5.5 × 8.5 <i>D</i>	7.9%	16%
10 offshore‡ DONG 2015	90-630 MW 30-175 WTG	10 layouts	one model	16%

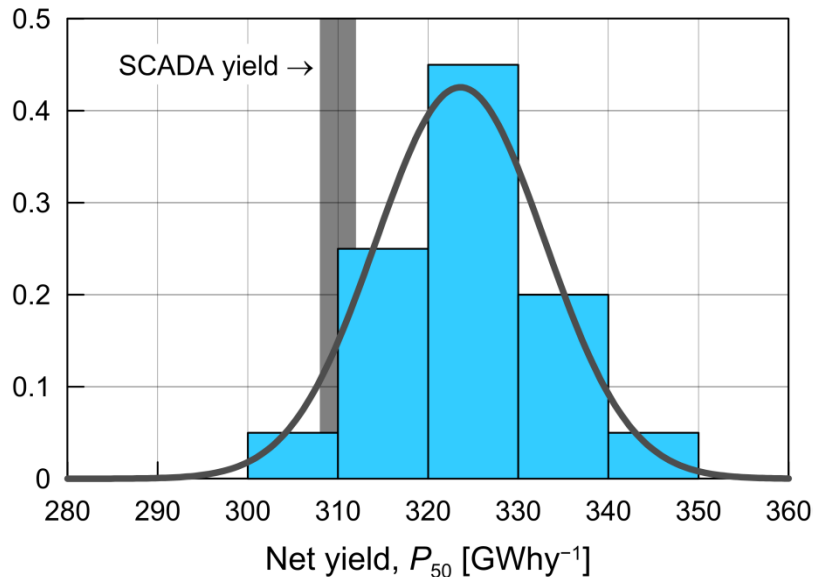
† Without two rather unusual outliers

‡ N.G. Nygaard, EWEA Offshore 2015

Uncertainty for offshore wind farm predictions



Barrow predicted vs observed P_{50} (1 year)



Data points used = 20 (of 22)

Mean predicted $P_{50} = 324 \text{ GWh}^{-1}$

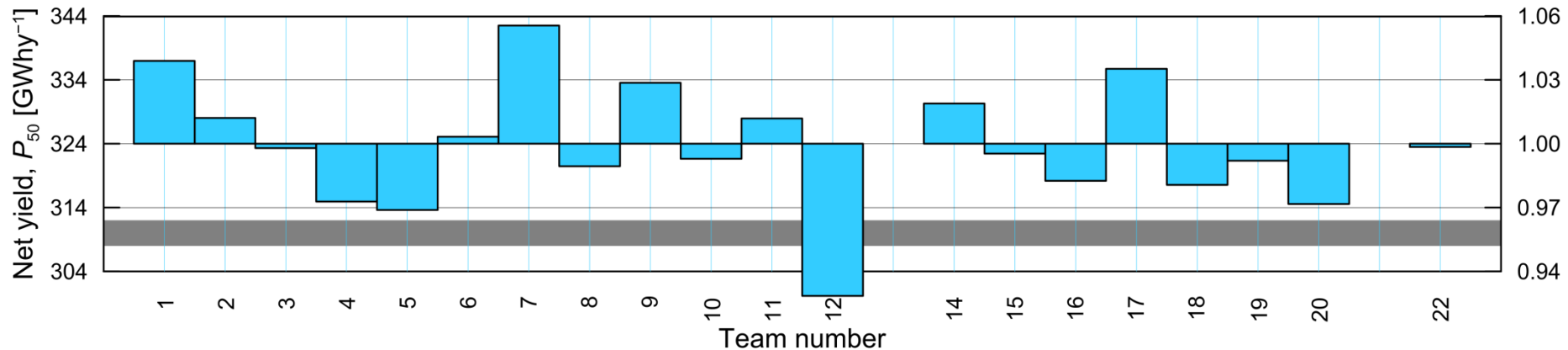
Standard deviation = 9.6 GWh^{-1}

Coefficient of variation = 3.0%

Range = 300 to 343 GWh^{-1}

Prediction bias = +4%

(cf. Cox, EWEA Offshore 2015)



Summary and conclusions – offshore wind farms

- Important issues offshore
 - Yield calculations
 - Wake modelling
 - Technical losses
 - Uncertainty estimation
- Wake modelling
 - Represent a significant loss
 - Uncertainty \propto WTG wake loss
 - Models and spec's important
 - Configuration essential too!
 - Classic models seem to provide realistic results for Barrow
 - Many more farms necessary...
- Yield assessment uncertainties
 - About 5-9% (minimum)
 - Consistent self-evaluation
- Modelled vs observed yields
 - Data for Barrow only
 - Estimated = 104% of obs. AEP
 - Spread (uncertainty) = 3%
- Standards and guidelines
 - Vocabulary and definitions
 - Best practice calculations and reporting
 - IEC, IEA, Measnet, ...
- 'Human factor' largely unknown

A photograph of an offshore wind farm at sunset. The sky is a gradient of blue and orange, and the sea is dark blue. Several wind turbines are visible, with the largest one in the foreground on the left. The text "Thank you for your attention!" is written in white, italicized font in the upper right area.

Thank you for your attention!

Handouts and papers from CREYAP exercises available from DTU web site

CREYAP references

- Mortensen, N. G., & Ejning Jørgensen, H. (2011). [Comparison of resource and energy yield assessment procedures](#). In *Proceedings*. European Wind Energy Association (EWEA).
- Mortensen, N. G., Ejning Jørgensen, H., Anderson, M., & Hutton, K-A. (2012). [Comparison of resource and energy yield assessment procedures](#). *Proceedings of EWEA 2012 - European Wind Energy Conference & Exhibition*. European Wind Energy Association.
- Mortensen, N. G., & Ejning Jørgensen, H. (2013). [Comparative Resource and Energy Yield Assessment Procedures \(CREYAP\) Pt. II](#). EWEA Technology Workshop: Resource Assessment, Dublin, Ireland, 26/06/13.
- Anderson, M., & Mortensen, N. G. (2013). [Comparative Resource and Energy Yield Assessment Procedures \(CREYAP\) Pt. II](#). AWEA Wind Resource & Project Energy Assessment Seminar, Las Vegas, NV, United States, 10/12/13.

Offshore

- Mortensen, N. G., Nielsen, M., & Ejning Jørgensen, H. (2013). [First Offshore Comparative Resource and Energy Yield Assessment Procedures \(CREYAP\)](#). EWEA Offshore 2013, Frankfurt, Germany, 19/11/13.
- Mortensen, N. G., & Nielsen, M. (2015). [Offshore CREYAP Part 2 – preliminary results](#). European Wind Energy Association (EWEA). EWEA Offshore 2015 Conference, Copenhagen, Denmark, 10/03/15.
- Mortensen, N. G., & Nielsen, M. (2015). [Offshore CREYAP Part 2 – final results](#). European Wind Energy Association (EWEA). EWEA Technology Workshop, Helsinki, Finland, 02/06/15.